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Comparison of AC GLONASS biases

Stefan Schaer¹, Michael Meindl²

¹Swiss Federal Office of Topography (swisstopo) / CODE@AIUB

²Astronomical Institute of the University of Bern (AIUB)



AC GLONASS bias files collected for comparison (GPS weeks 1666-1667)

- **COD** Center for Orbit Determination in Europe, AIUB, Switzerland
 - Bernese DCB
- **EMR** Natural Resources Canada, Canada
 - no GLONASS bias information (GLONASS biases ignored in GNSS clock analysis)
- **ESA** European Space Operations Center, ESA, Germany
 - bias-SINEX (first two days of GPS week 1666 missing)
- **GFZ** GeoForschungsZentrum, Germany
 - bias-SINEX
- **GRG** GRGS-CNES/CLS, Toulouse, France
 - modified Bernese DCB
- **IAC** Information-Analytical Centre, Russia
 - PBS format
- **JPL** Jet Propulsion Laboratory, USA
 - GIPSY time dependent parameter format (wrong weeks)

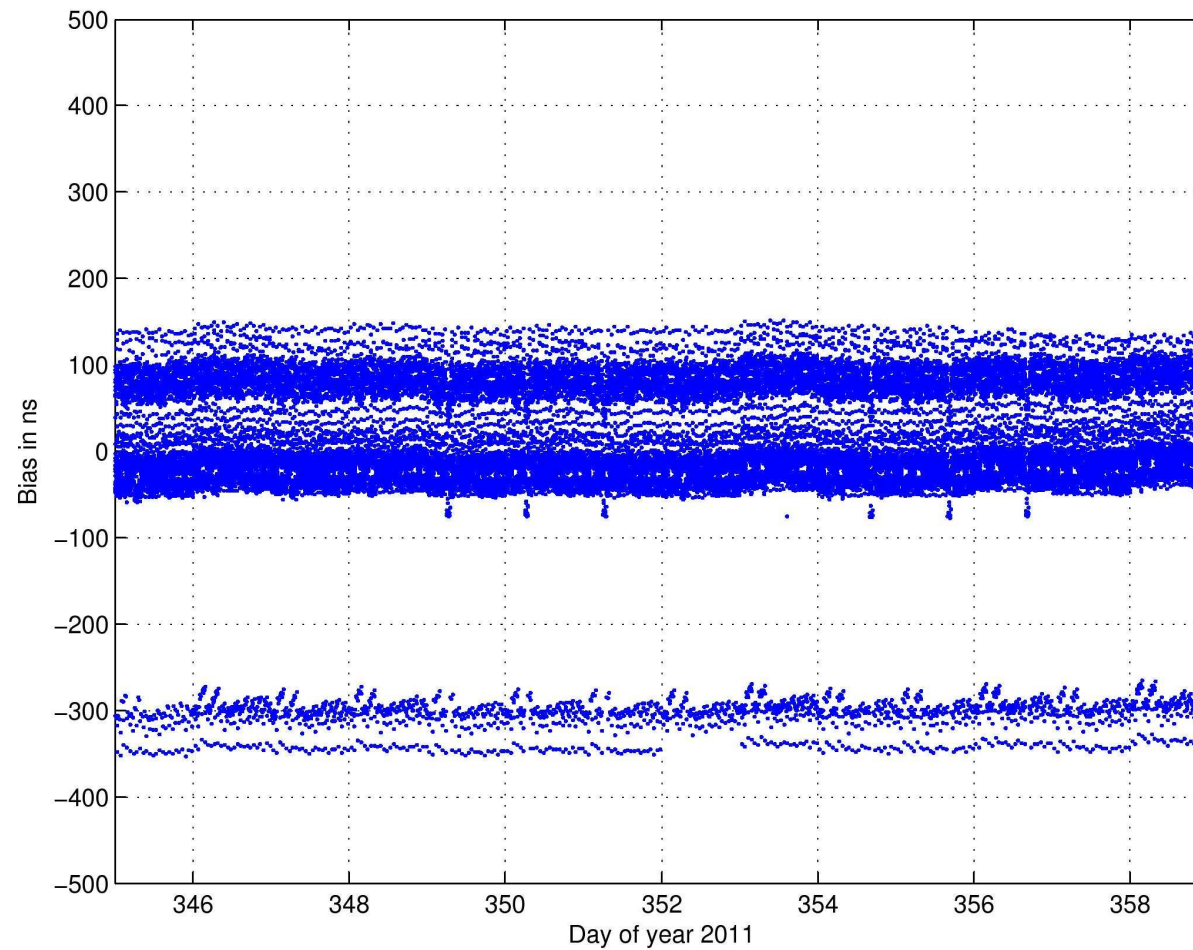


GLONASS bias data used for comparison

AC	Format	Number of files	Remark
COD	DCB	14	
ESA	Bias-SINEX	12	2 missing days
GFZ	Bias-SINEX	14	
GRG	Modified DCB	14	
IAC	PBS	14	
JPL	GIPSY format	7	not used due to late submission and wrong week

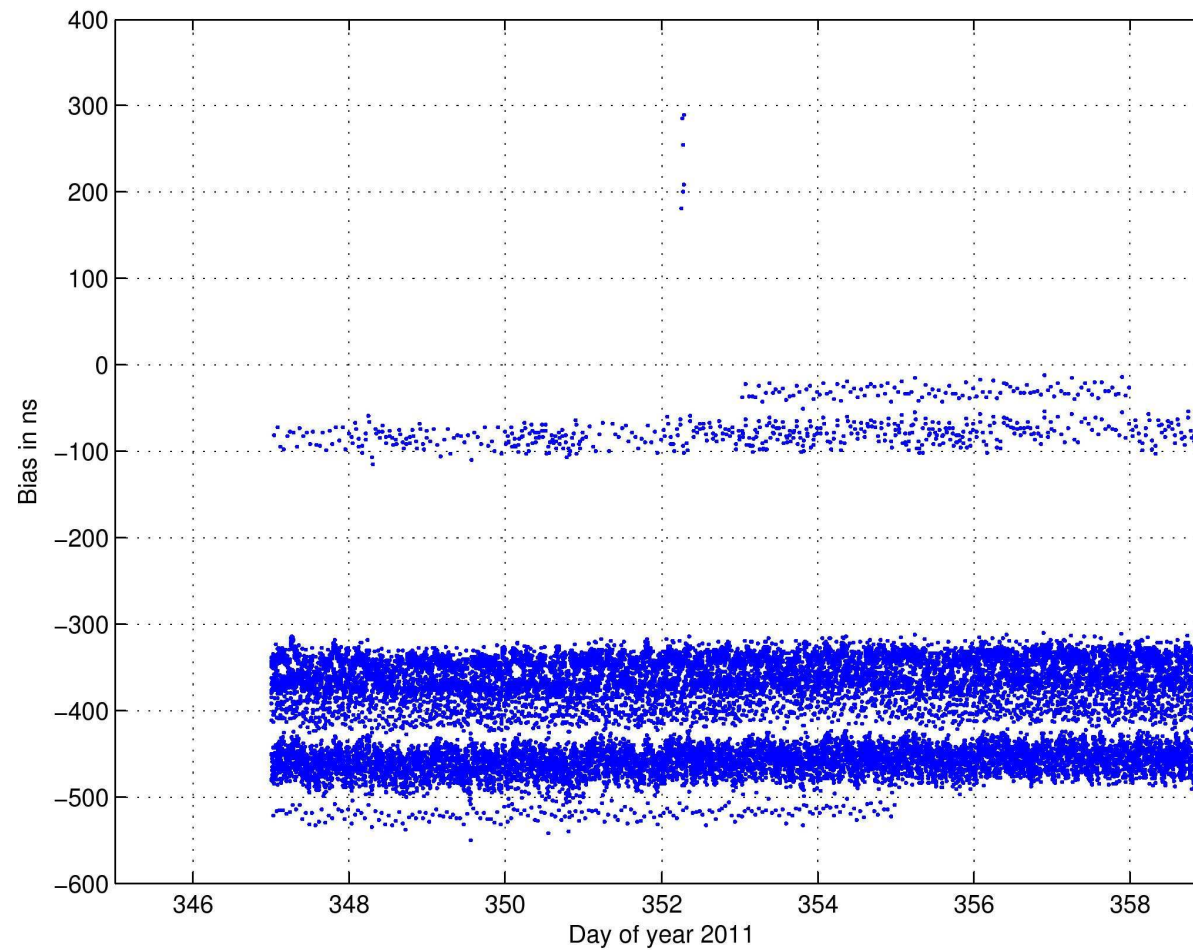


GLONASS biases as delivered by: COD



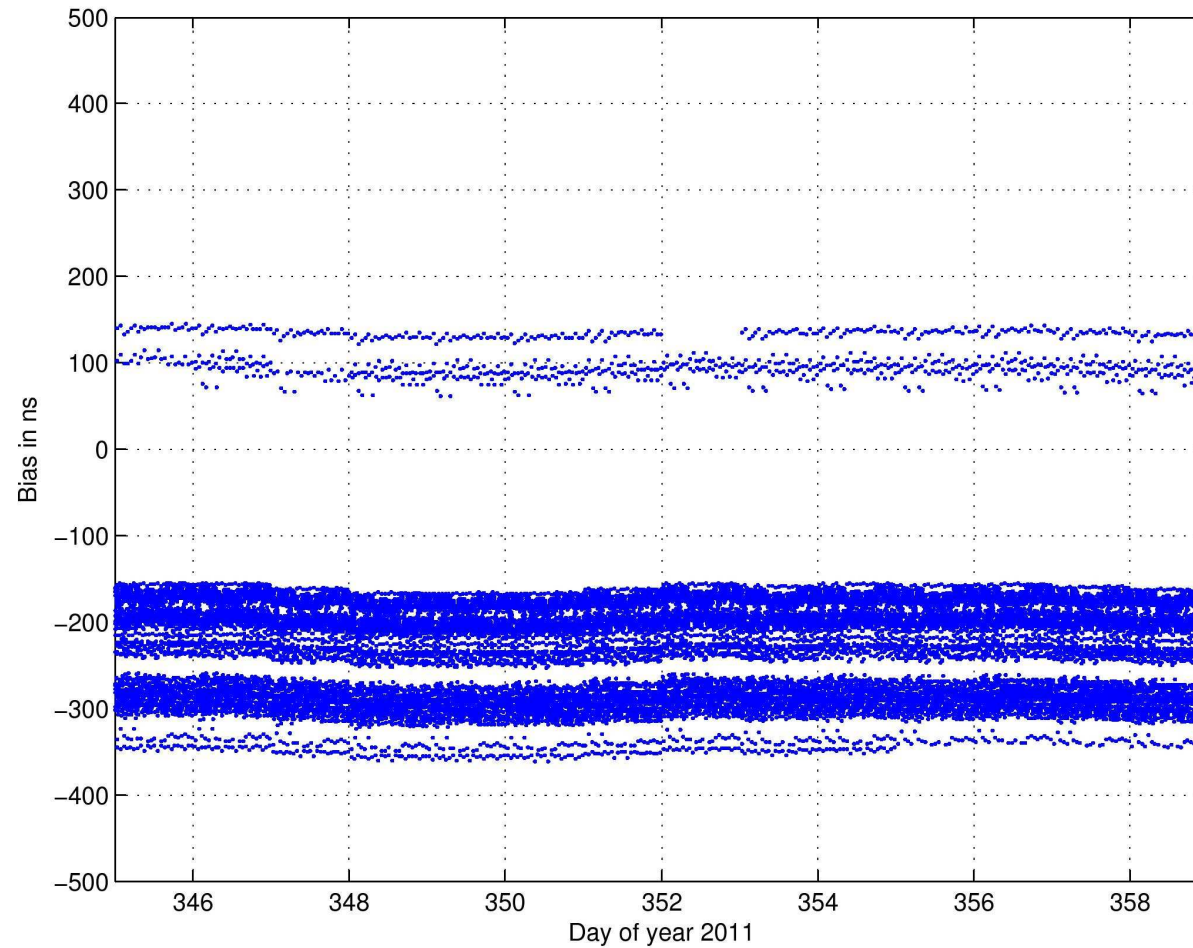


GLONASS biases as delivered by: ESA



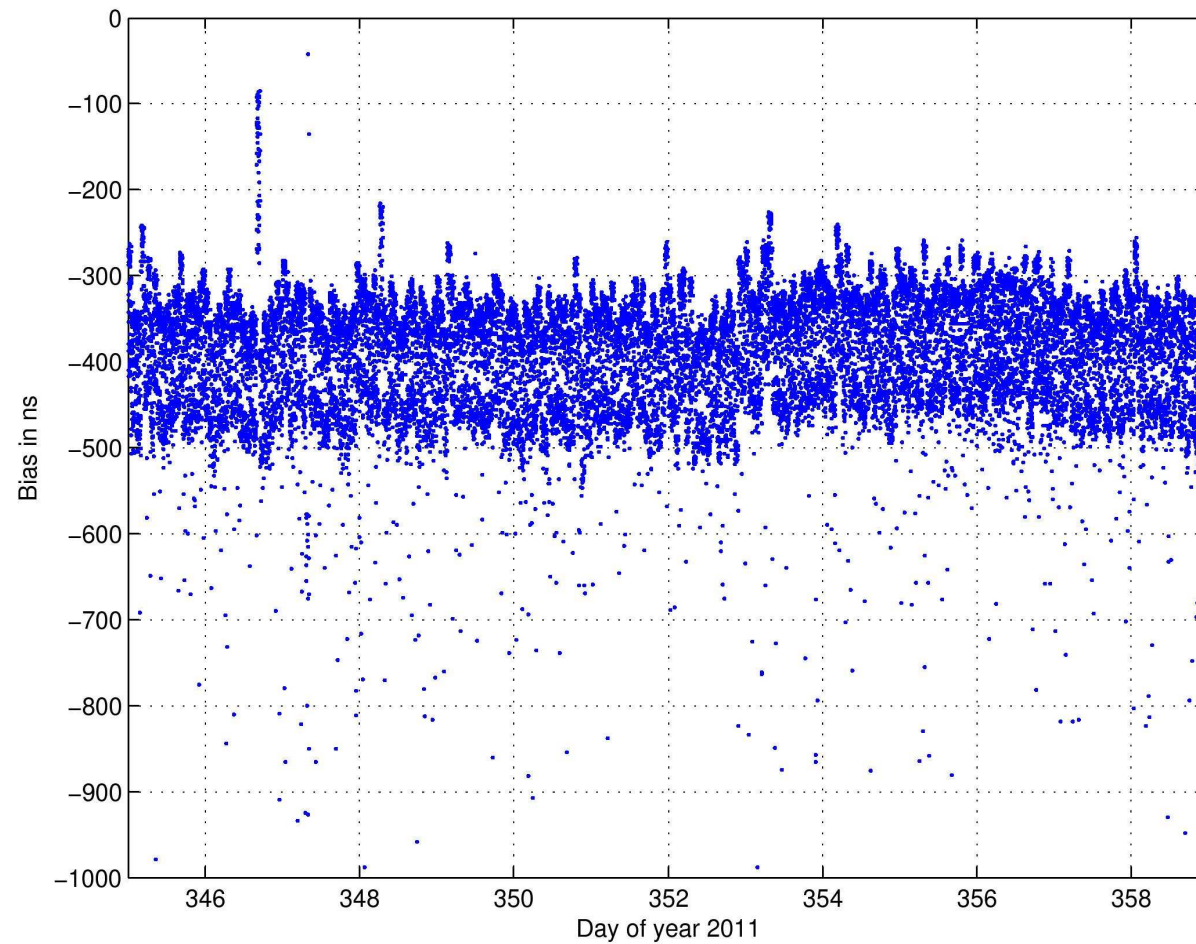


GLONASS biases as delivered by: GFZ



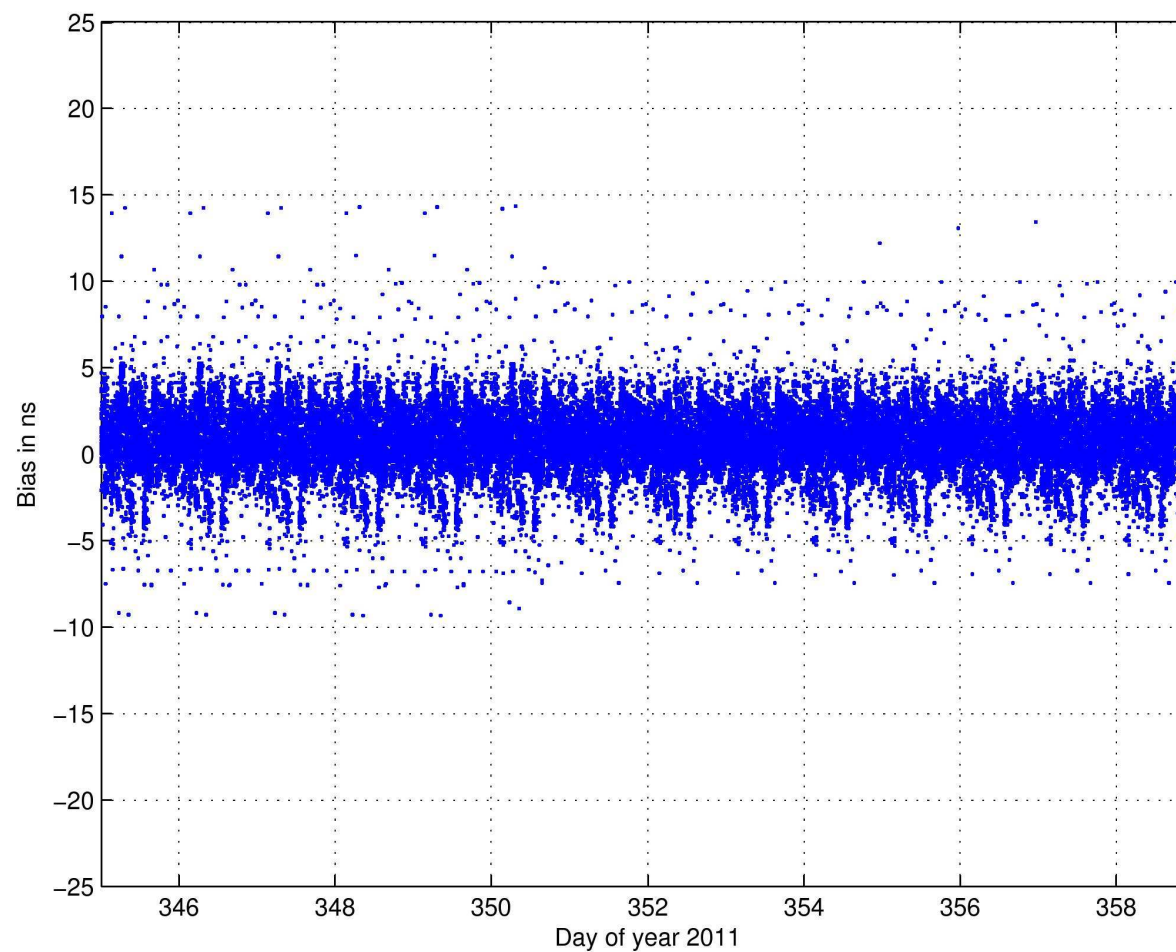


GLONASS biases as delivered by: GRG



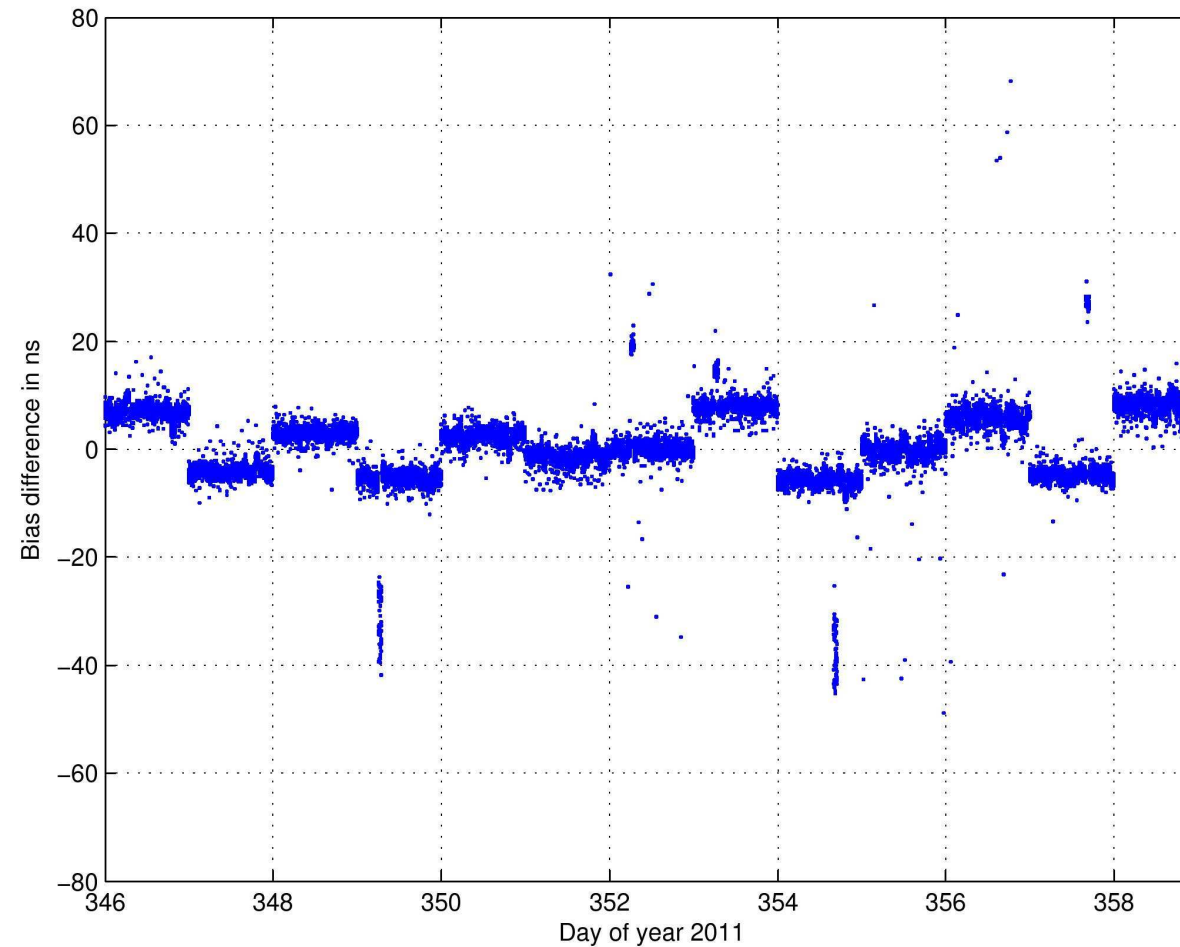


GLONASS biases as delivered by: IAC



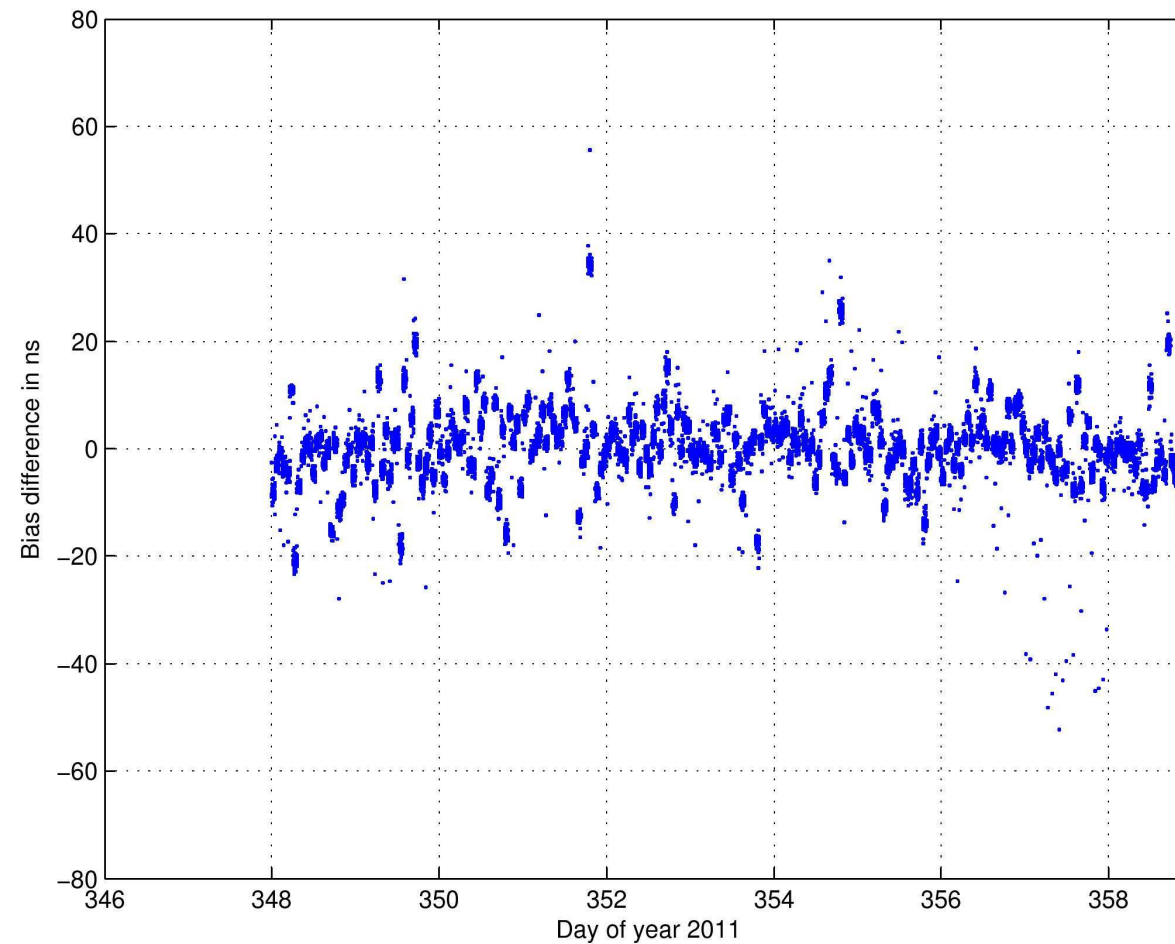


Day-to-day repeatability/differences of GLONASS biases: COD



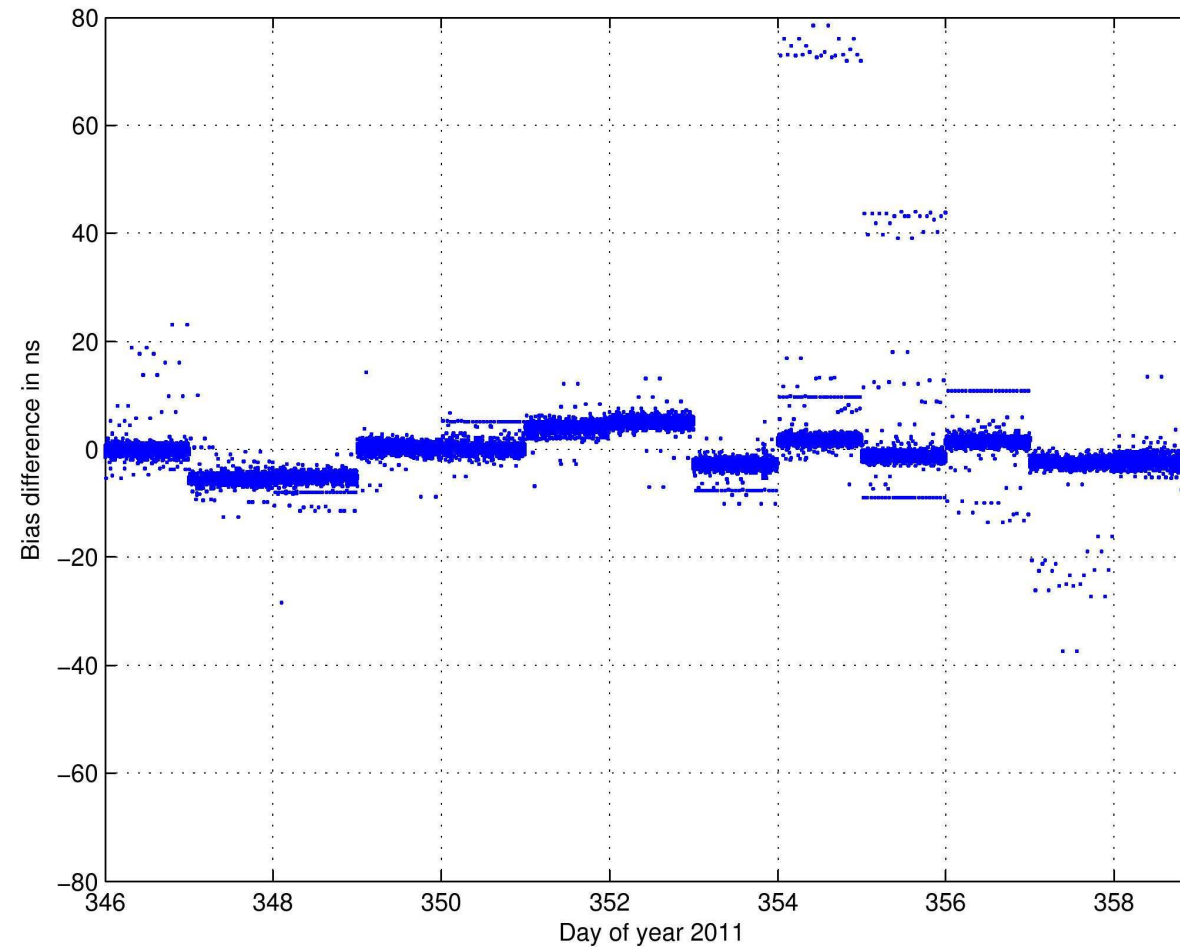


Day-to-day repeatability/differences of GLONASS biases: ESA



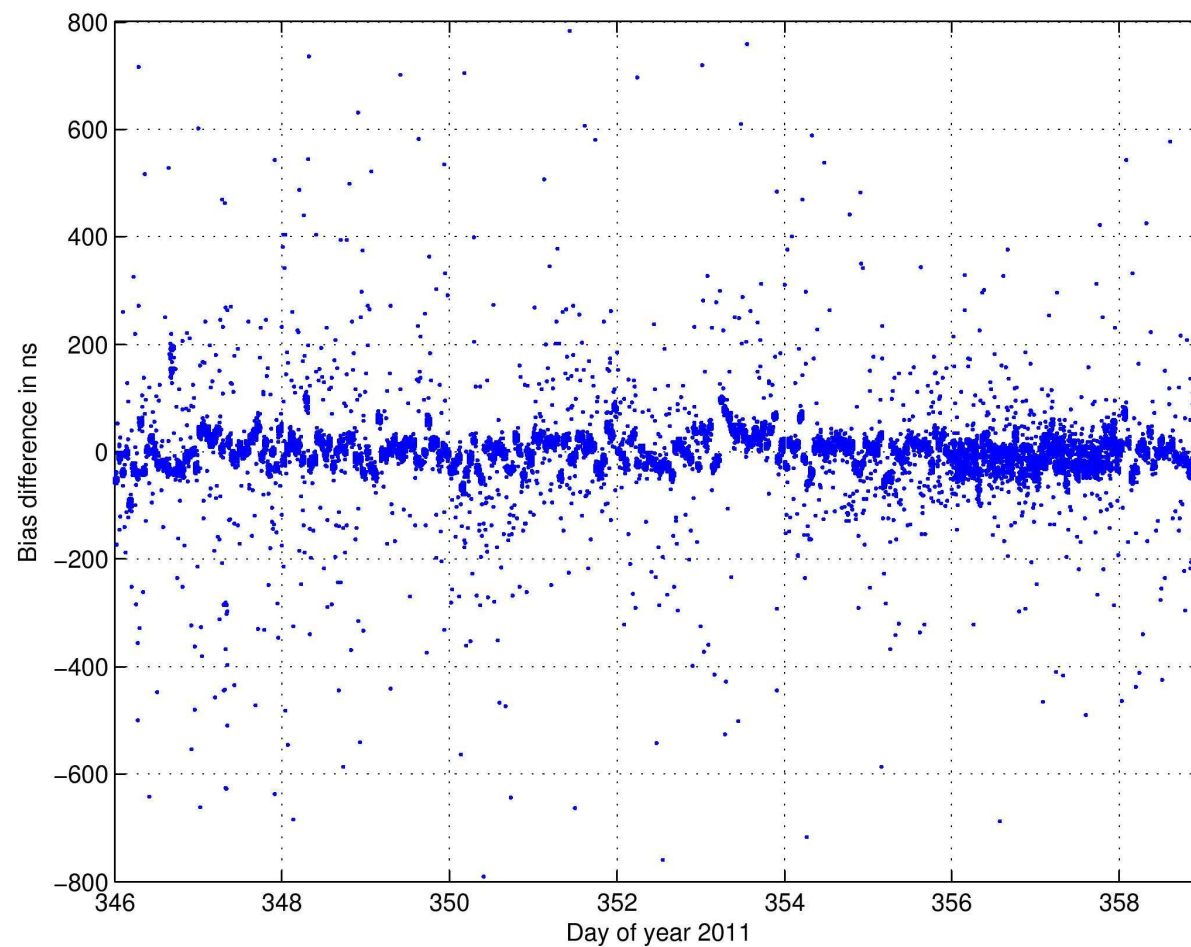


Day-to-day repeatability/differences of GLONASS biases: GFZ



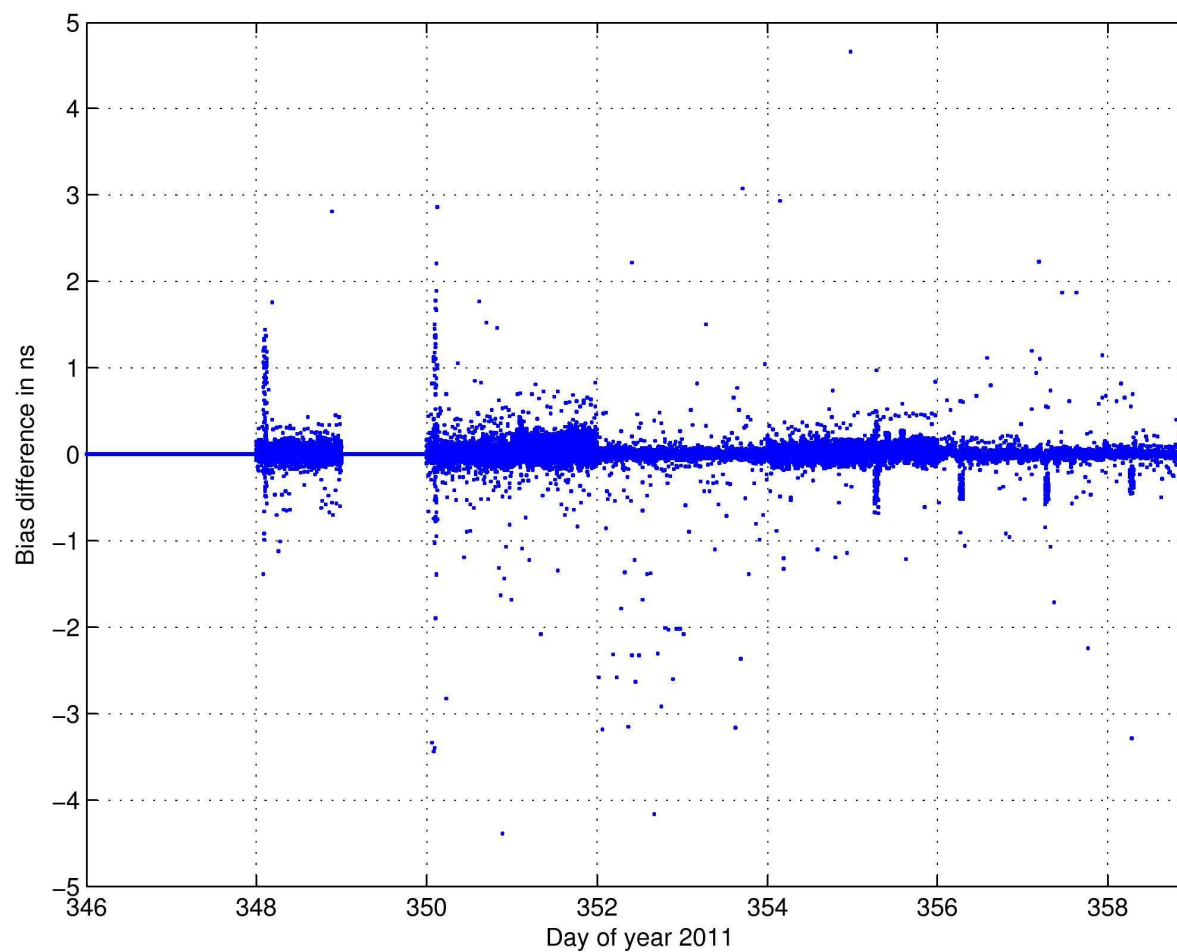


Day-to-day repeatability/differences of GLONASS biases: GRG



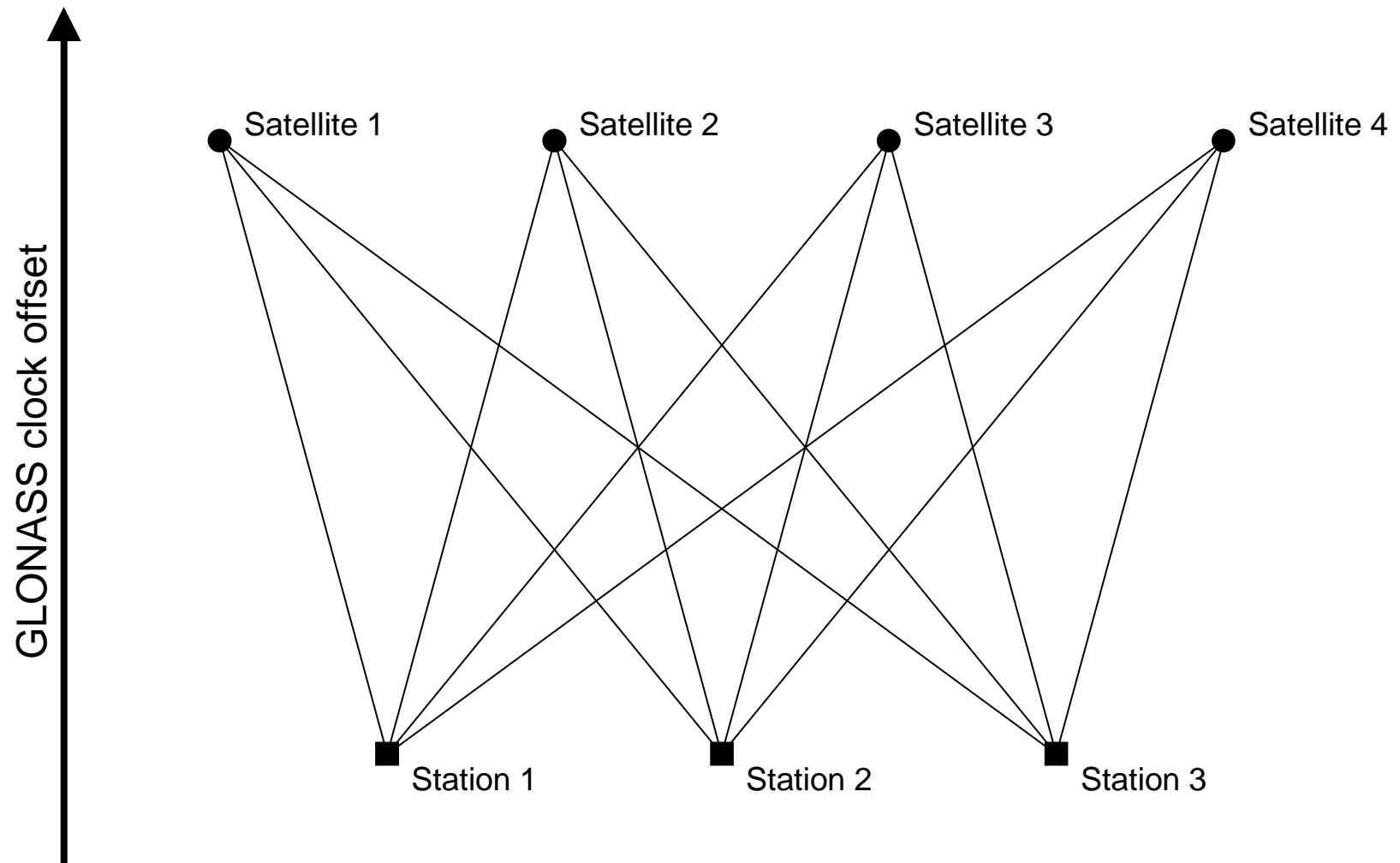


Day-to-day repeatability/differences of GLONASS biases: IAC



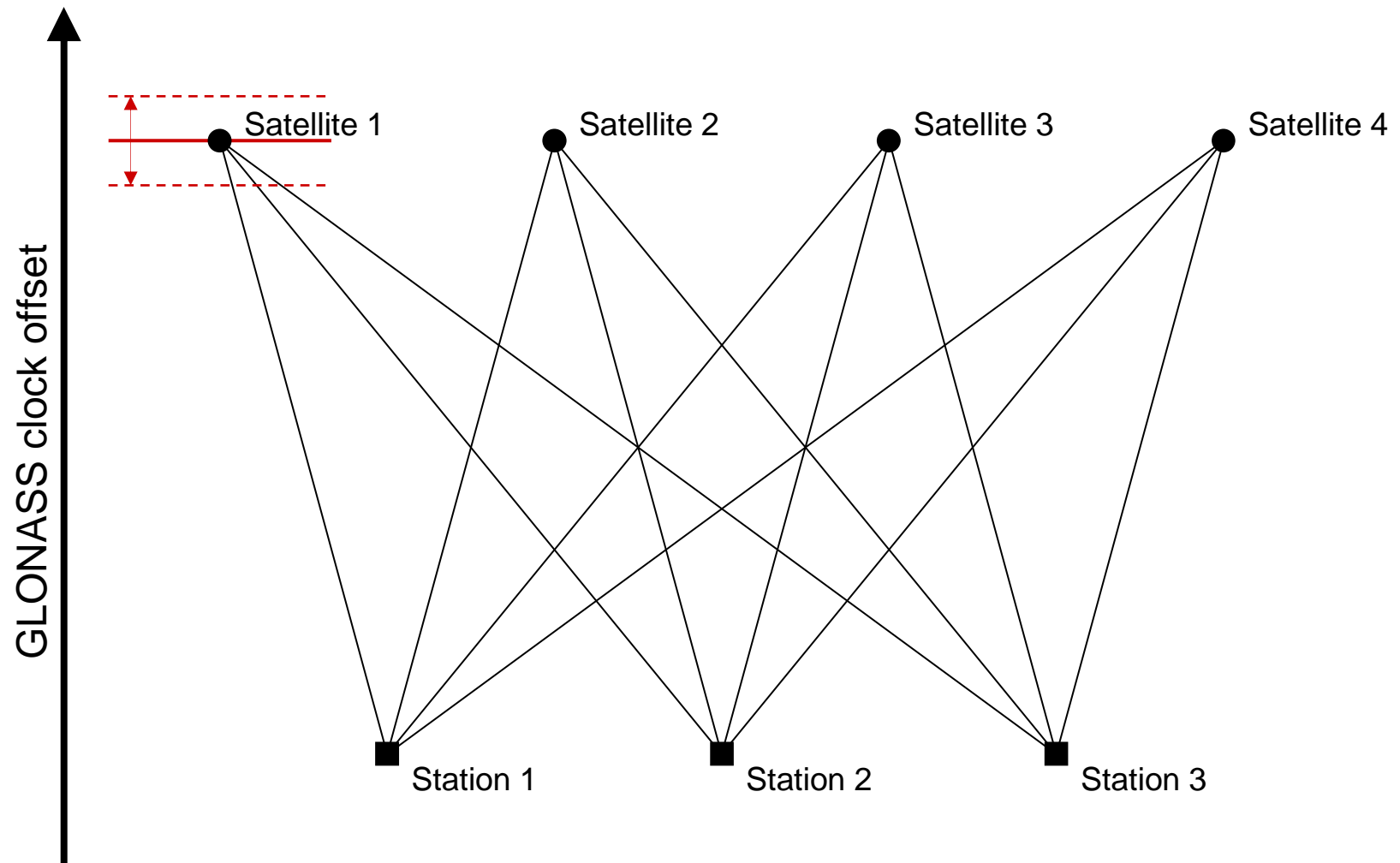


Datum definition for GLONASS biases (1)



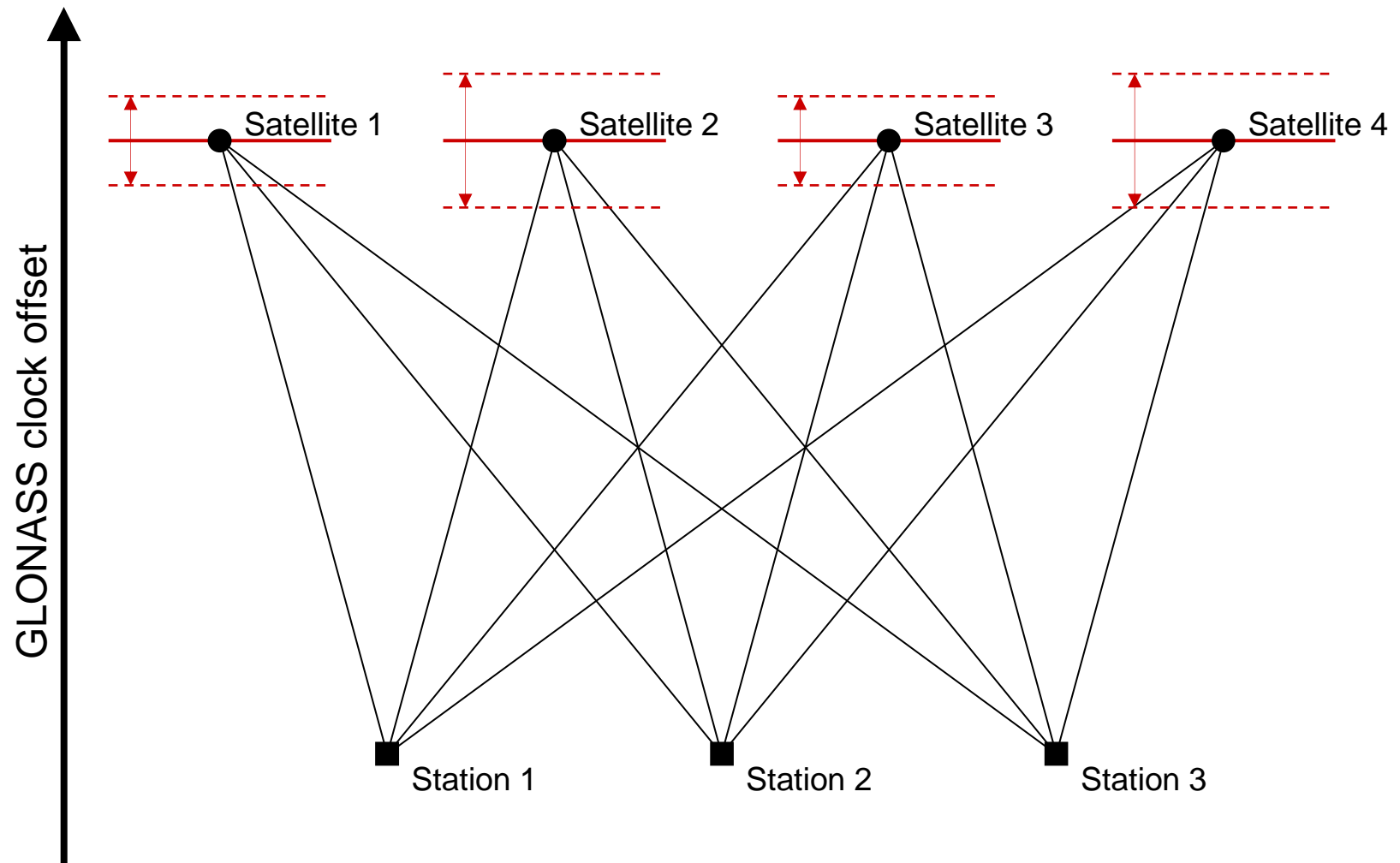


Datum definition for GLONASS biases (2)



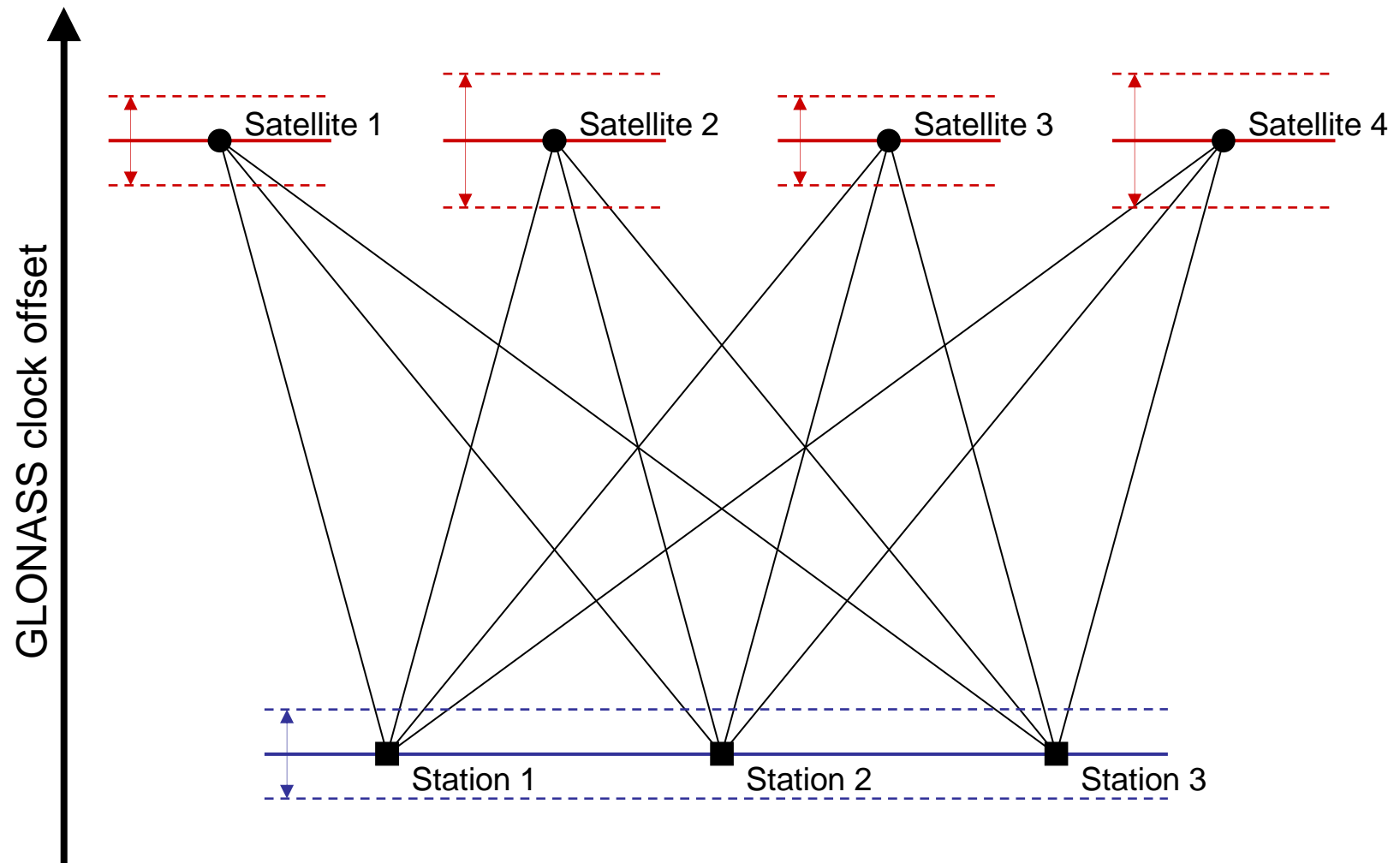


Datum definition for GLONASS biases (3)





Datum definition for GLONASS biases (4)



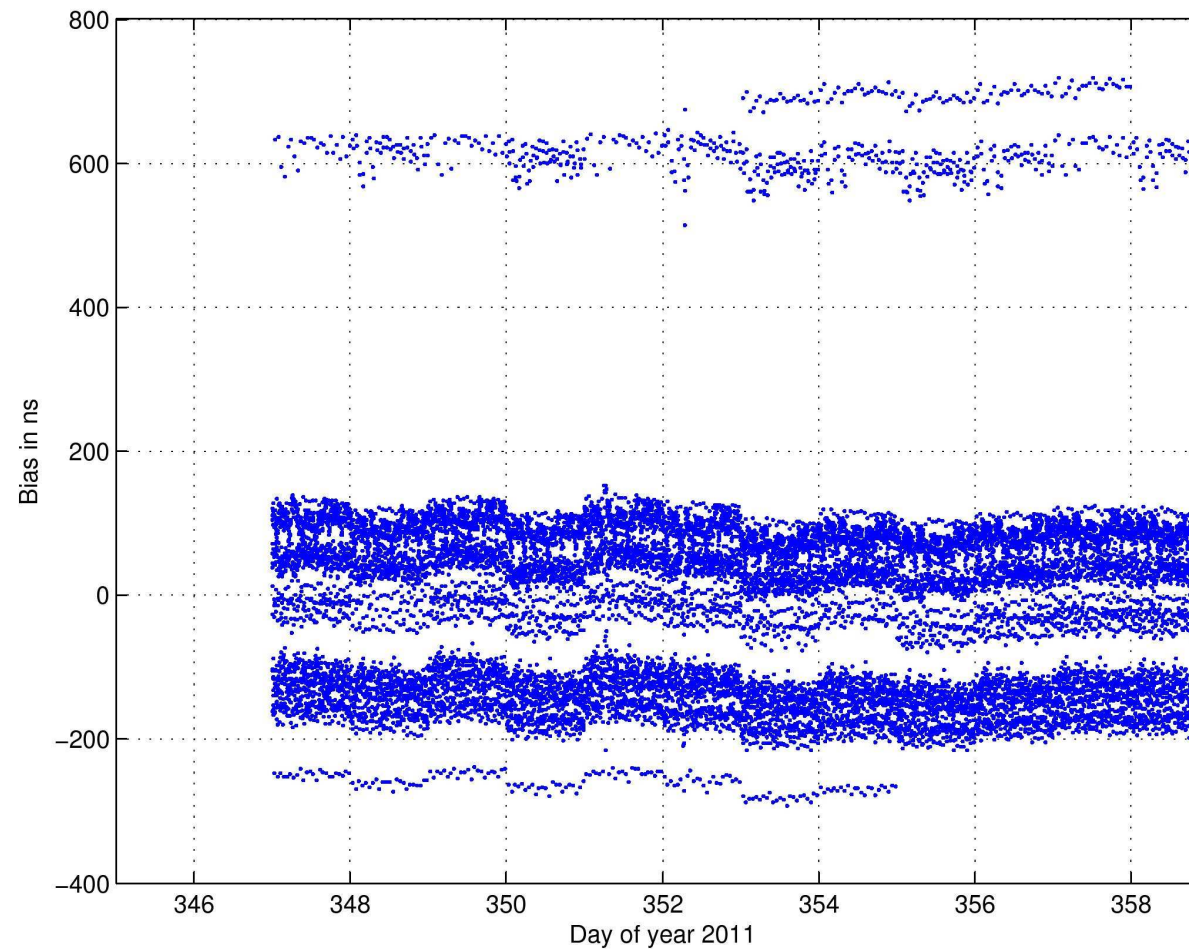


Datum definition for GLONASS biases (5)

- Conclusion:
 - consistency of each AC GLONASS clock product is not affected by adding an arbitrary constant to:
 - all bias values referring to a particular GLONASS satellite
 - all bias values
 - we expect that differences between two sets of AC GLONASS clock corrections show similar differences for all bias values referring to a particular GLONASS satellite
- Comparison strategy:
 - form differences of corresponding satellite-station biases and subtract one constant (mean) for each satellite

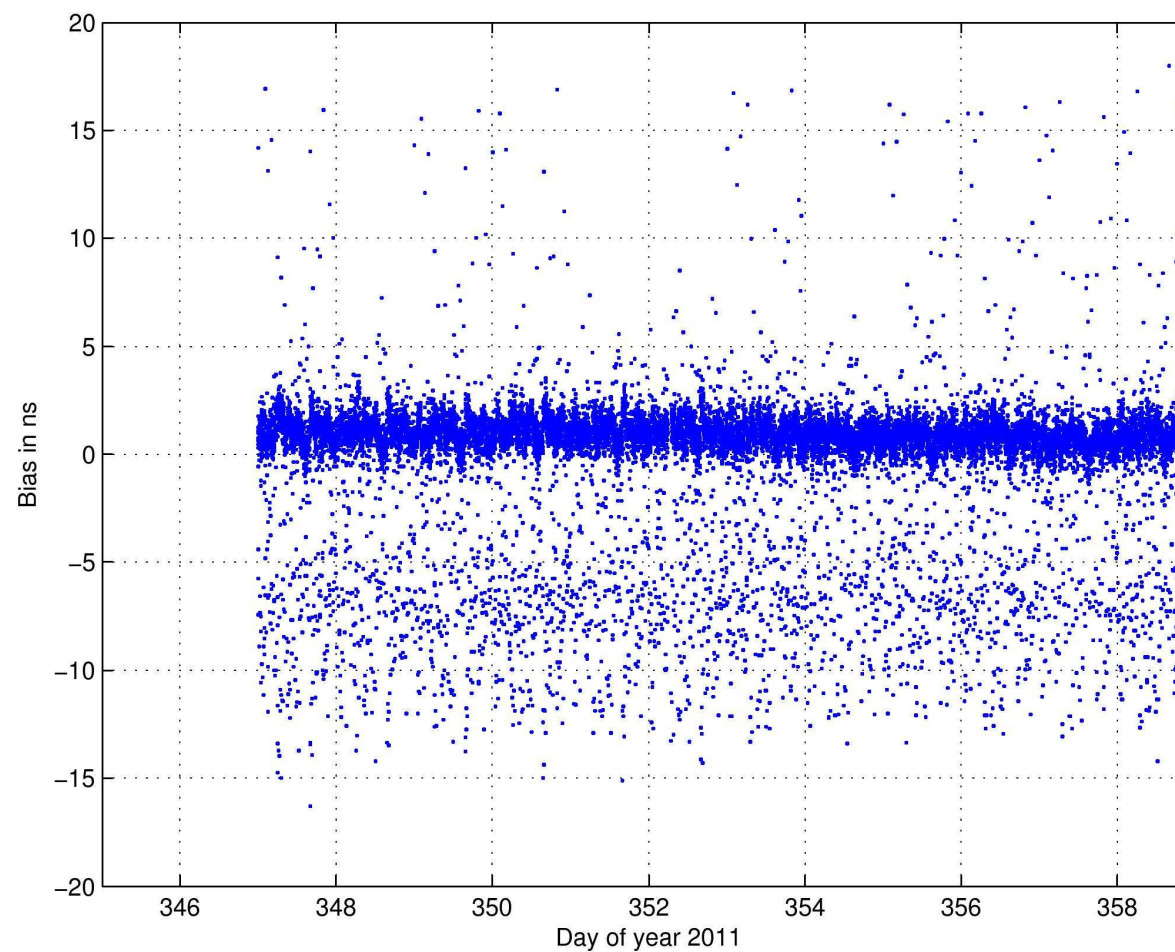


AC GLONASS bias comparison: COD-ESA (1)



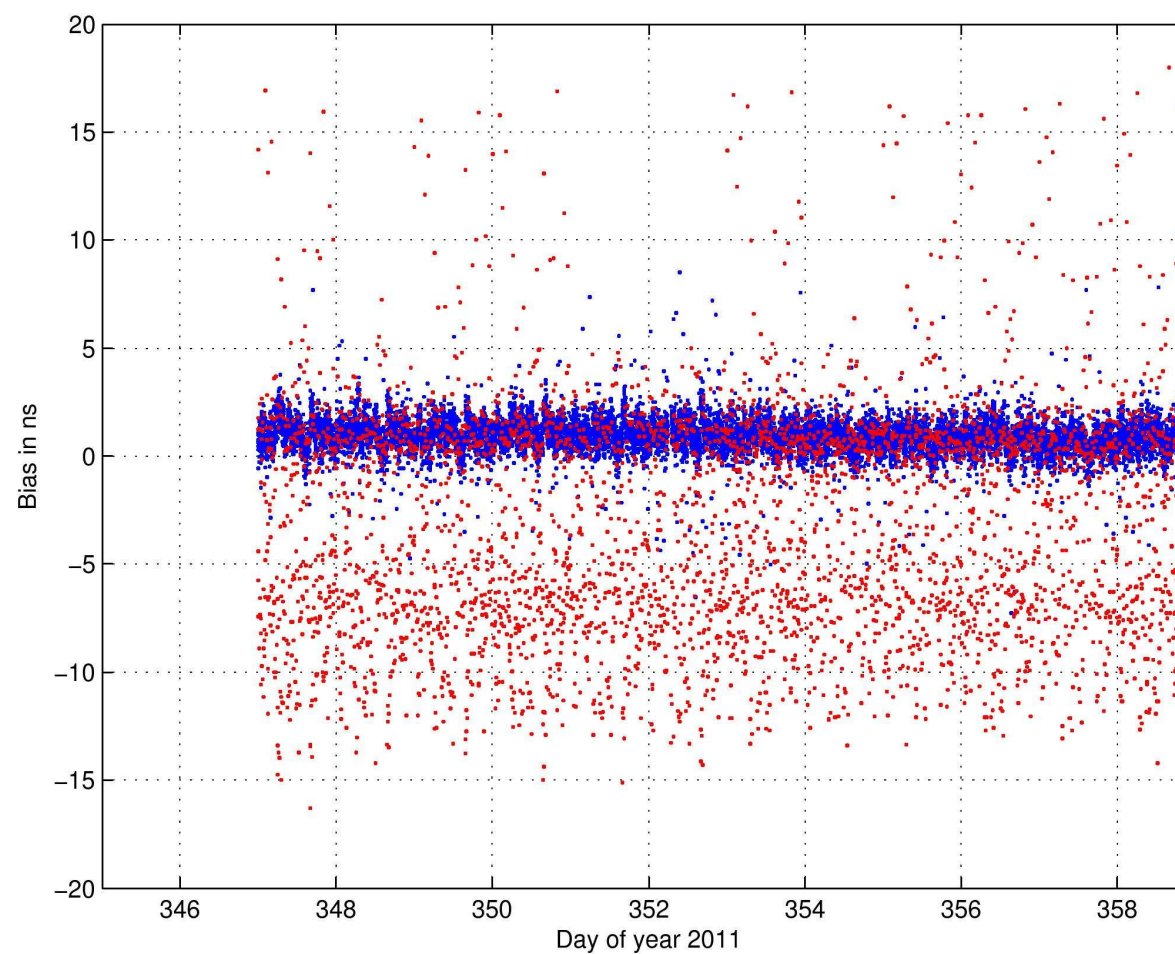


AC GLONASS bias comparison: COD-ESA (2) → sign changed



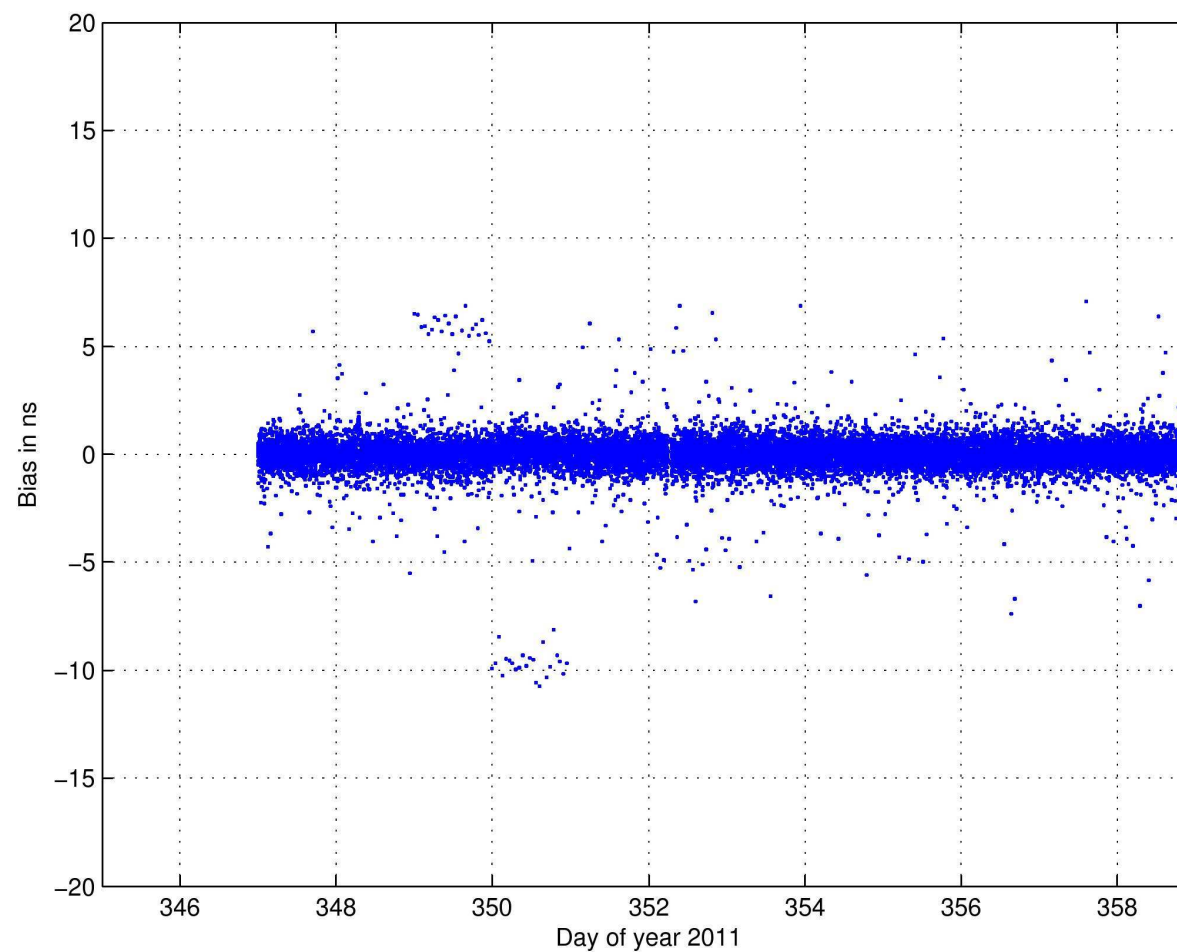


AC GLONASS bias comparison: COD-ESA (2) → sign changed



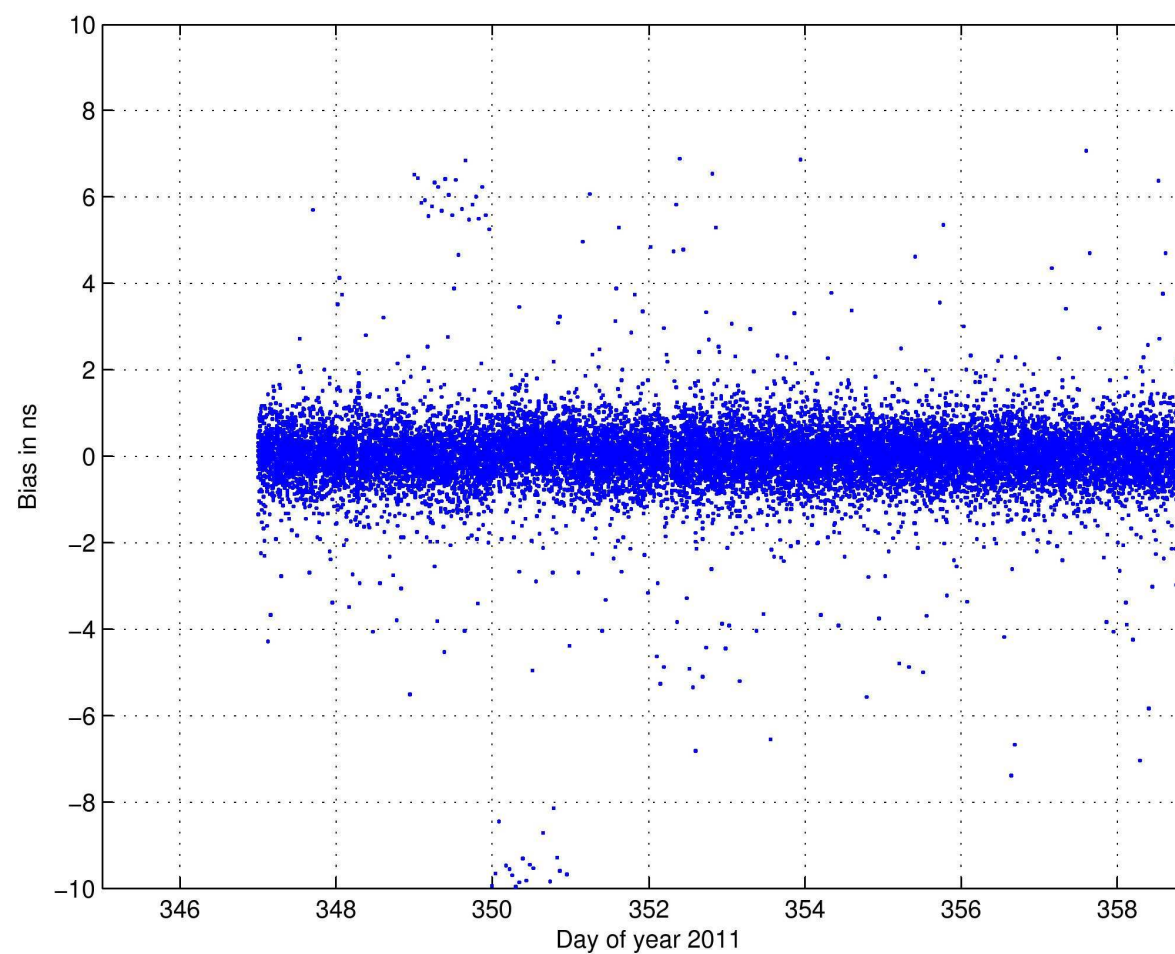


AC GLONASS bias comparison: COD-ESA (3) → P1-C1 DCB corrected



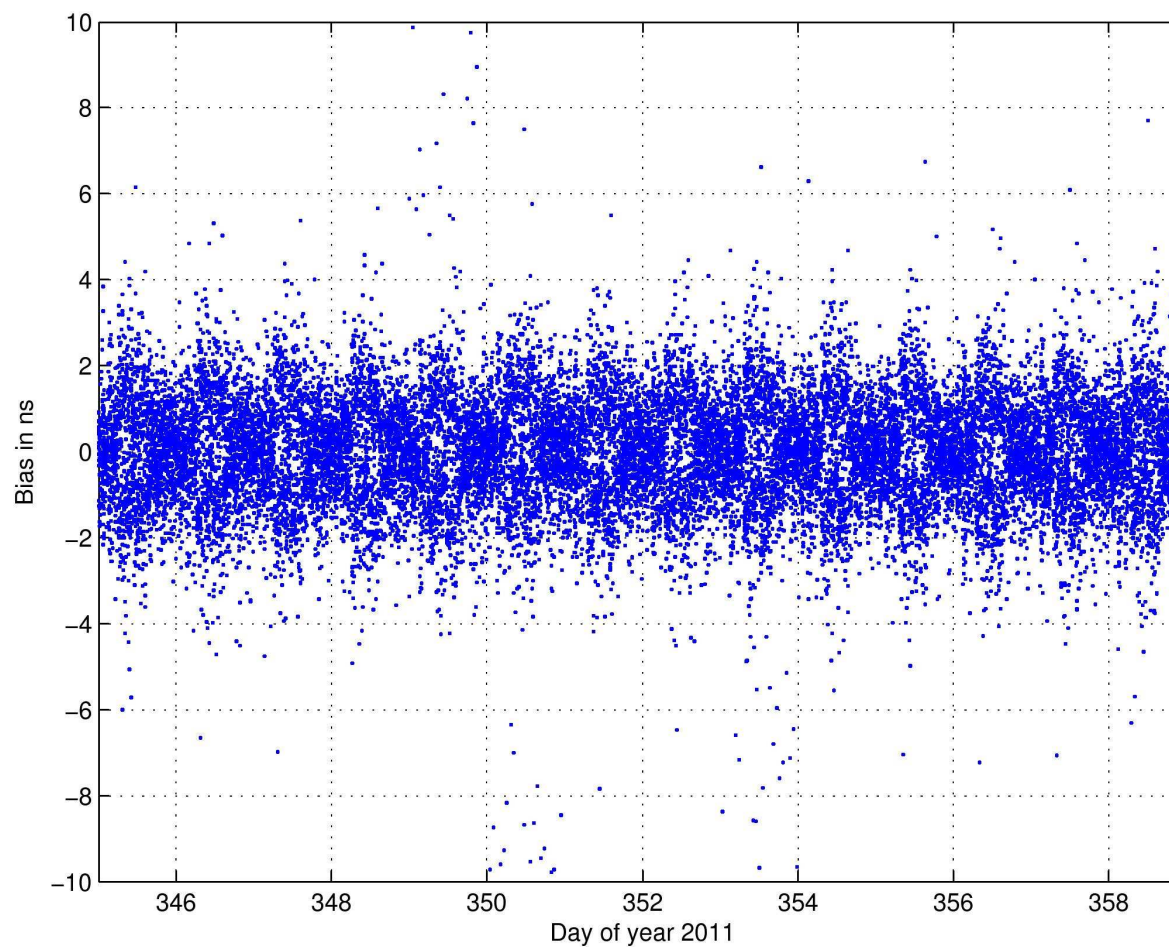


AC GLONASS bias comparison: COD-ESA



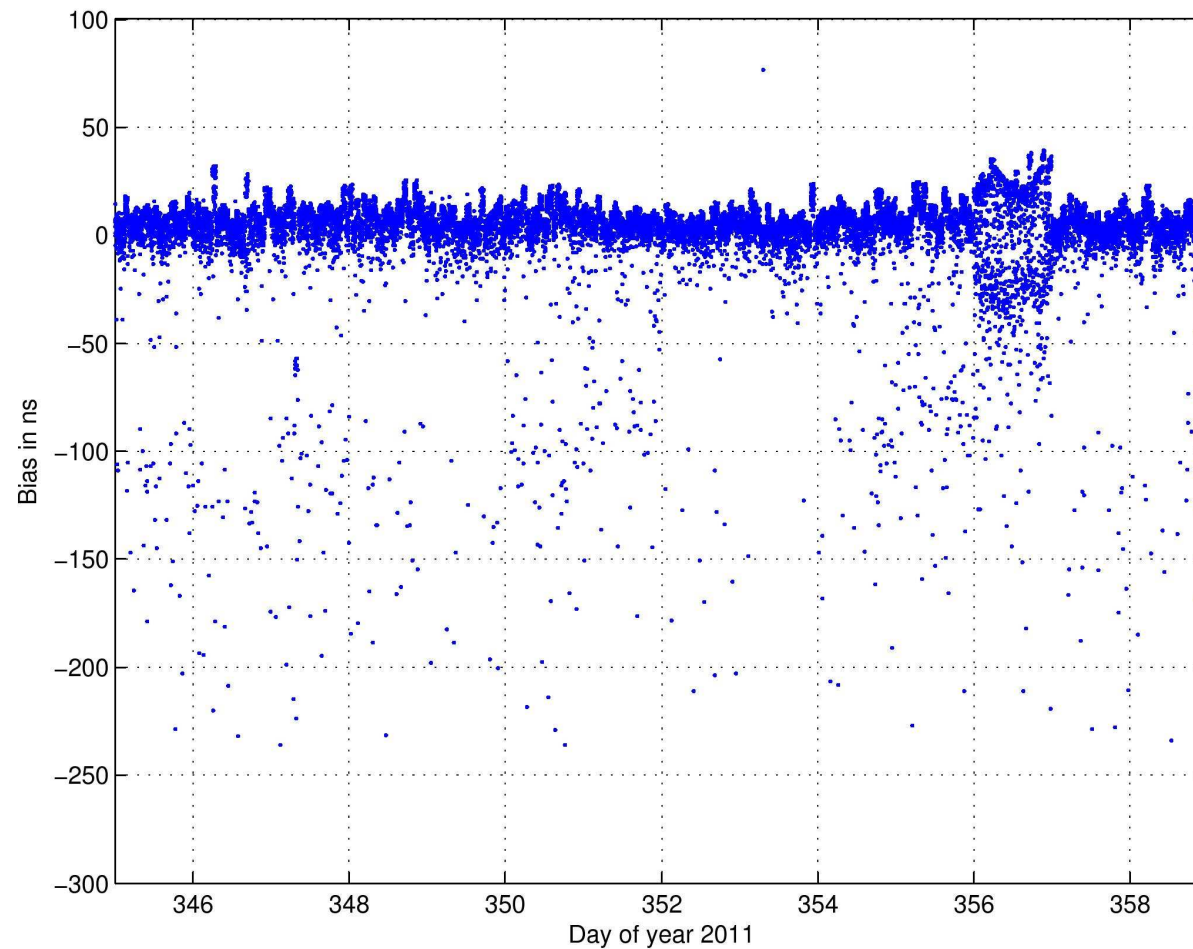


AC GLONASS bias comparison: COD-GFZ



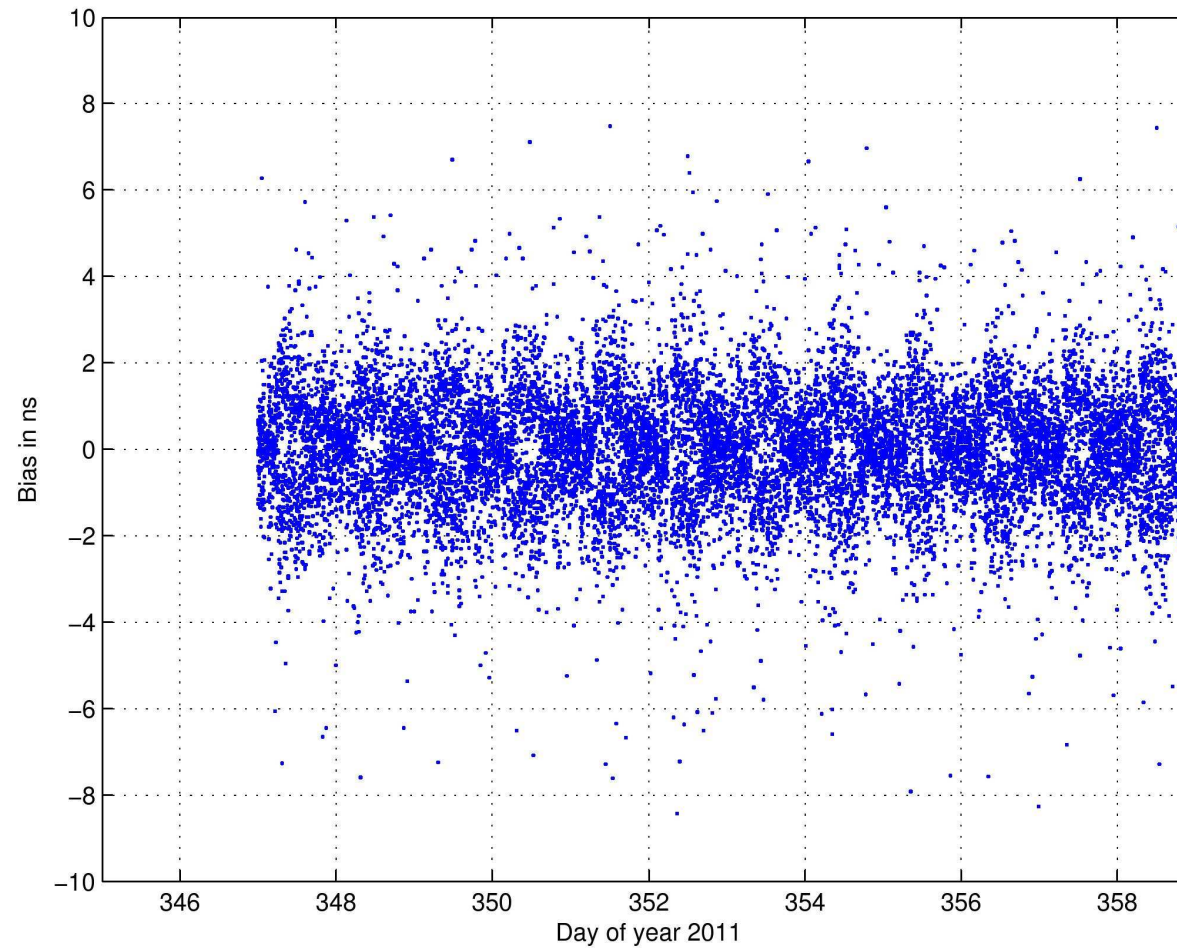


AC GLONASS bias comparison: COD-GRG



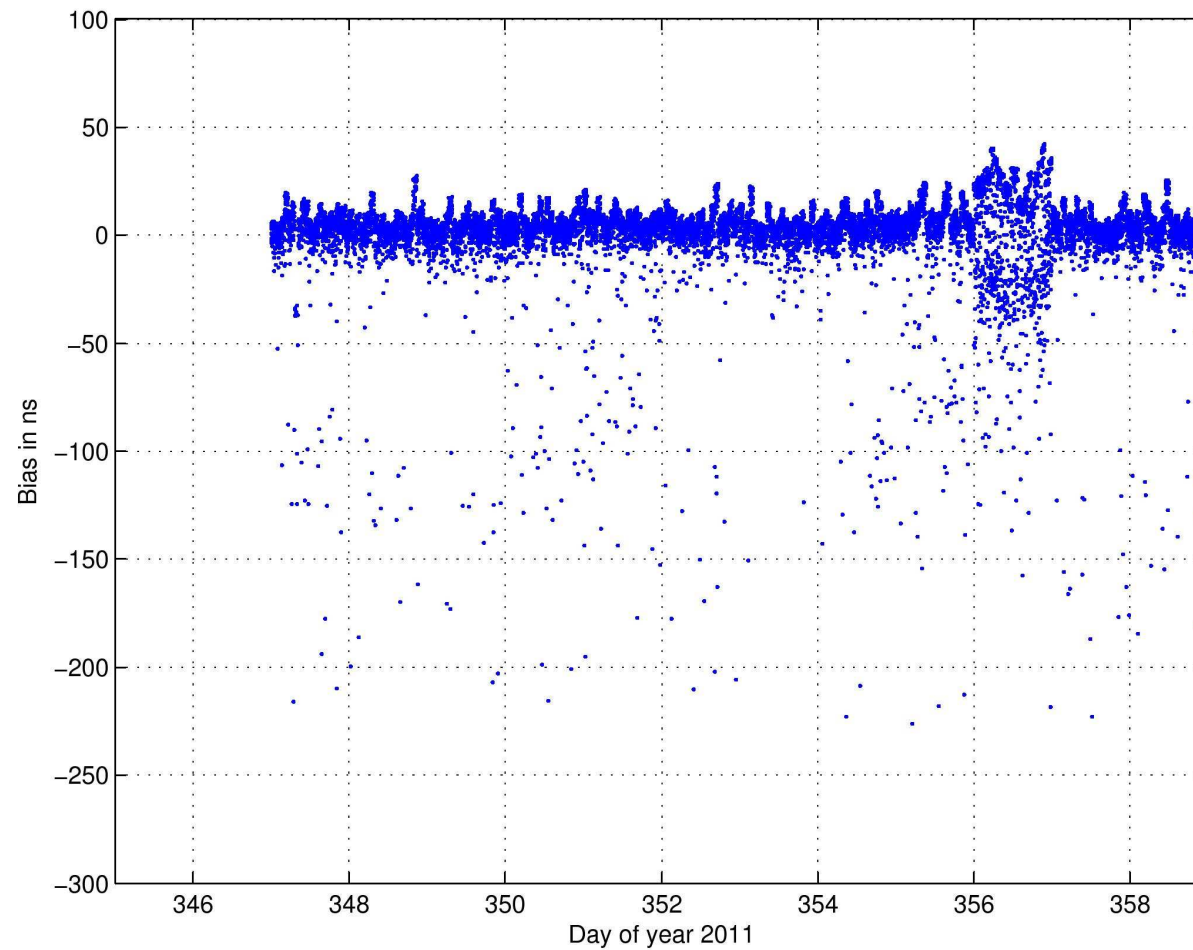


AC GLONASS bias comparison: ESA-GFZ



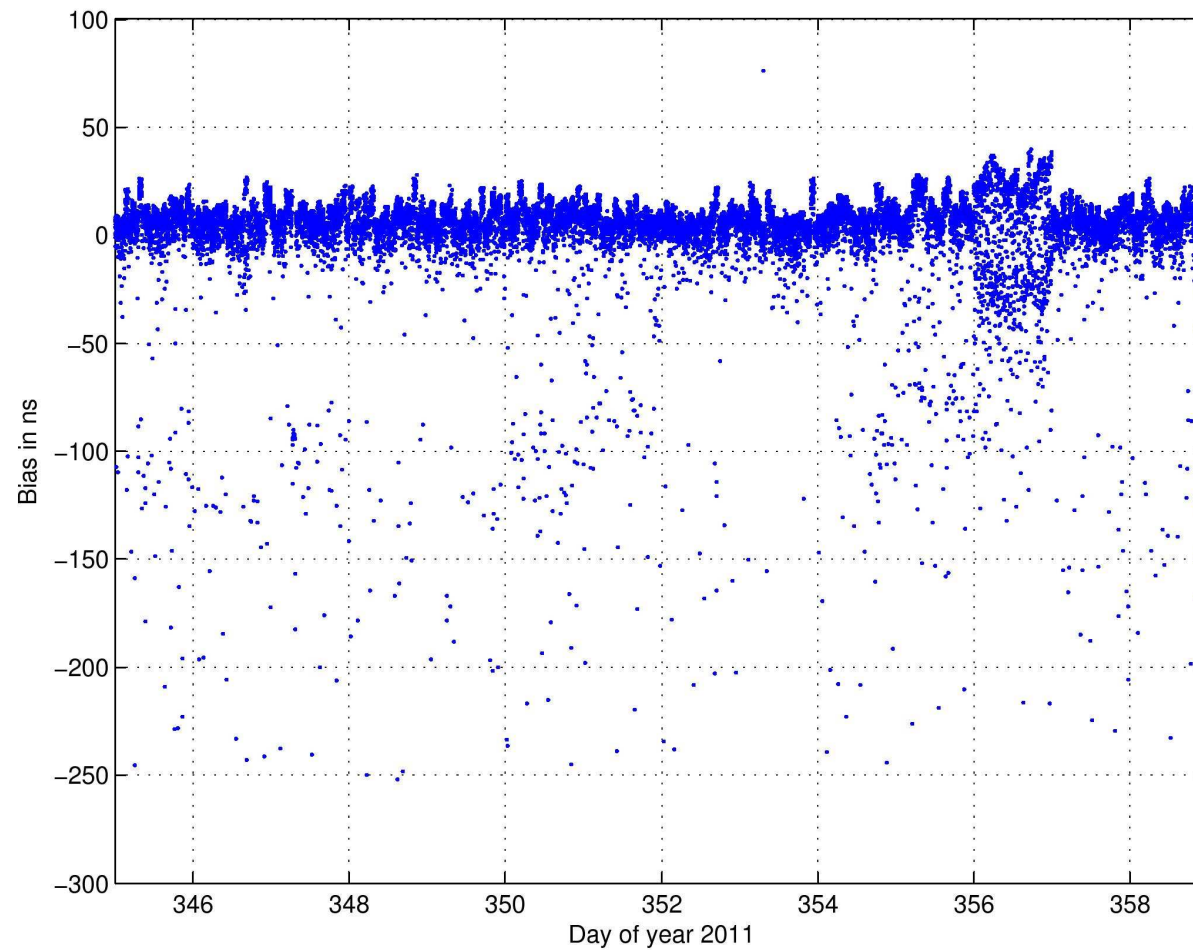


AC GLONASS bias comparison: ESA-GRG





AC GLONASS bias comparison: GFZ-GRG





Summary of AC GLONASS bias comparison (1)

AC	Median (ns)	Mean (ns)	Std (ns)
COD-ESA	0.01	0	0.79
COD-GFZ	0.02	0	1.33
COD-GRG	5.63	1.87	23.12
ESA-GFZ	0.01	0	1.34
ESA-GRG	4.14	1.29	20.63
GFZ-GRG	6.00	1.72	25.23



Summary of AC GLONASS bias comparison (2)

AC	Compared biases	Outliers
COD-ESA	17045	54
COD-GFZ	22618	0
COD-GRG	16759	97
ESA-GFZ	14997	51
ESA-GRG	12252	51
GFZ-GRG	15776	81

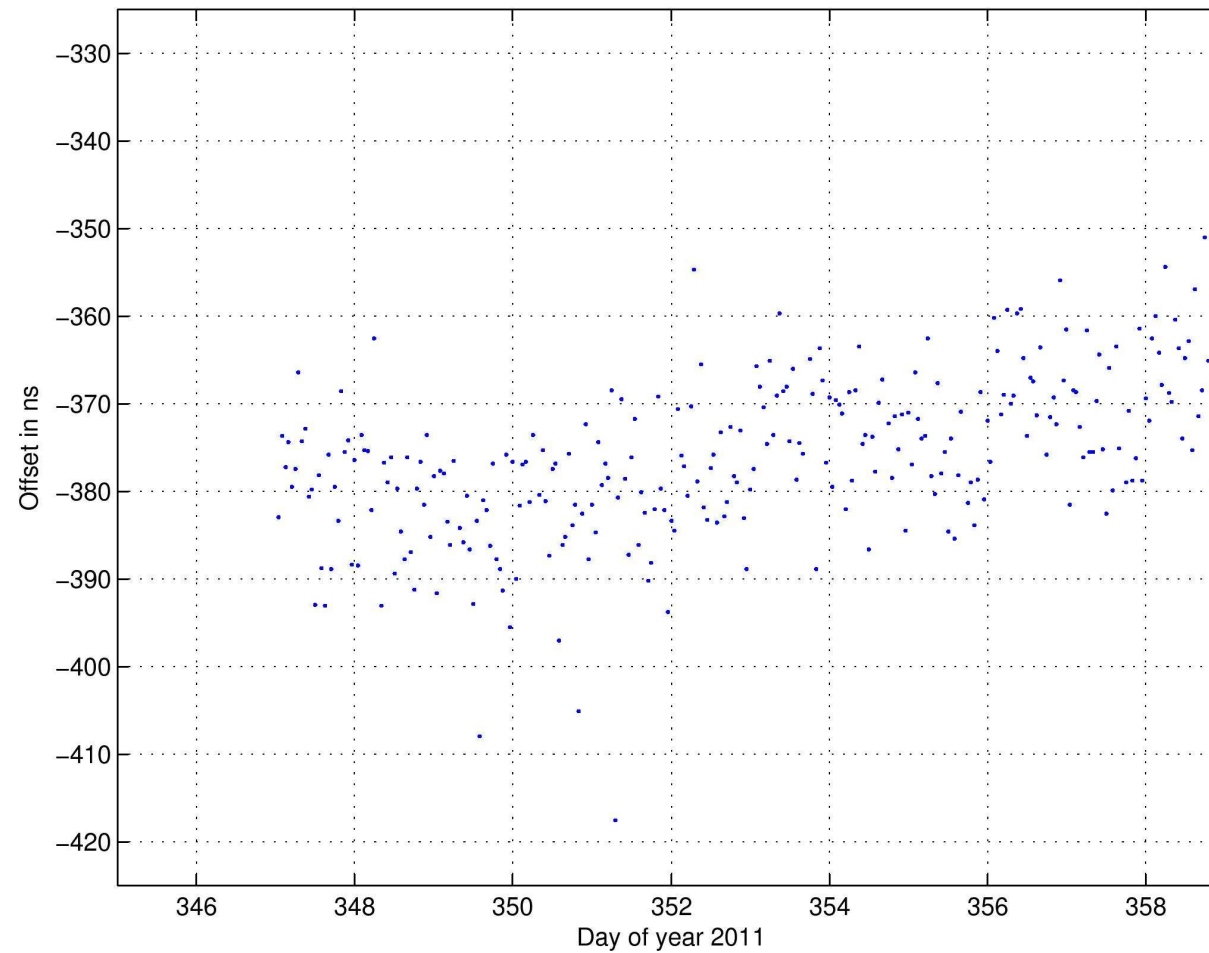


Datum definition for GLONASS biases

- Conclusion:
 - consistency of each AC GLONASS clock product is not affected by adding an arbitrary constant to:
 - all bias values referring to a particular GLONASS satellite
 - all bias values
 - we expect that differences between two sets of AC GLONASS clock corrections show similar differences (or differences with one common expectation value) for all bias values referring to a particular GLONASS satellite
- Comparison strategy:
 - form differences of corresponding satellite-station biases and subtract one constant (mean) for each satellite
 - **change sign**
 - **apply station-specific GLONASS P1-C1 corrections**

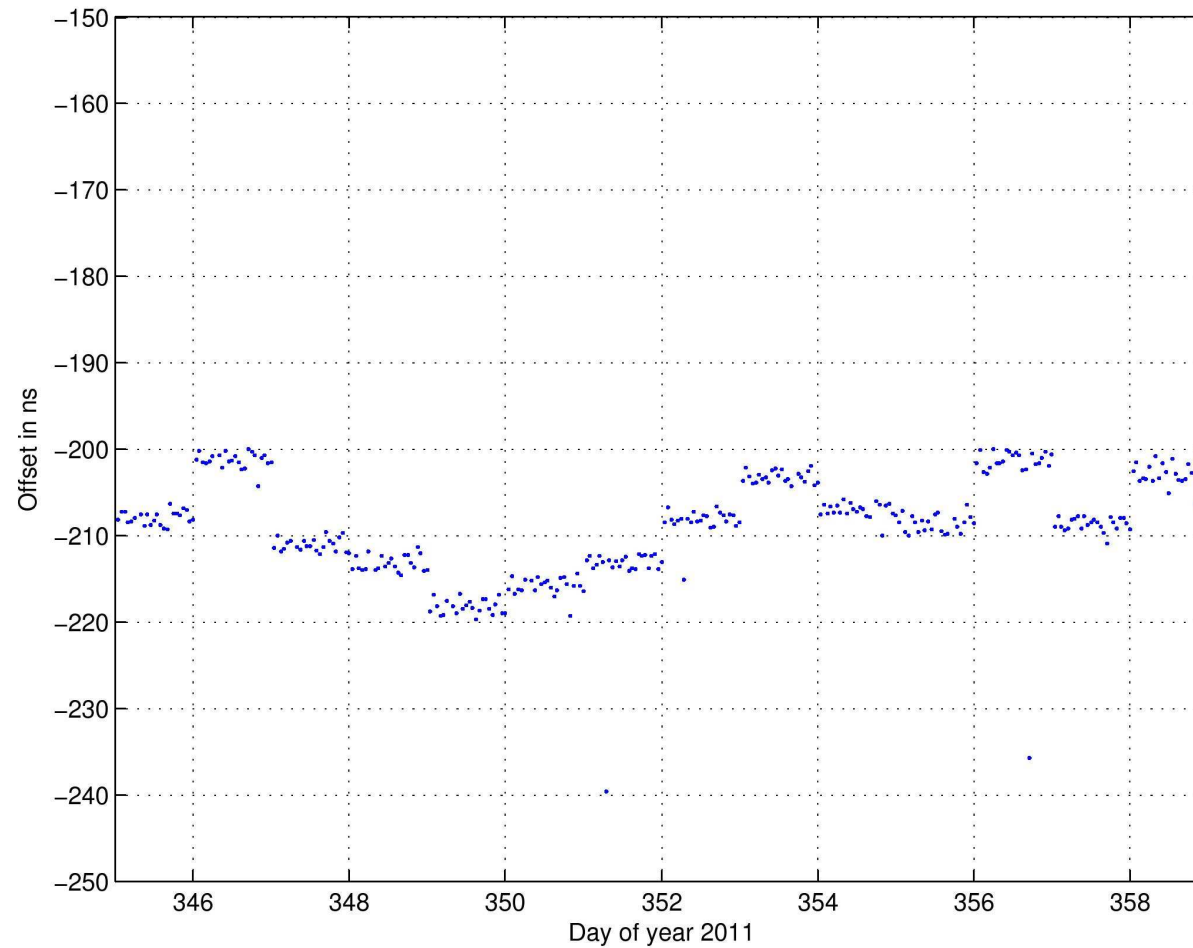


Inter-AC GLONASS bias offsets (per sat): COD-ESA



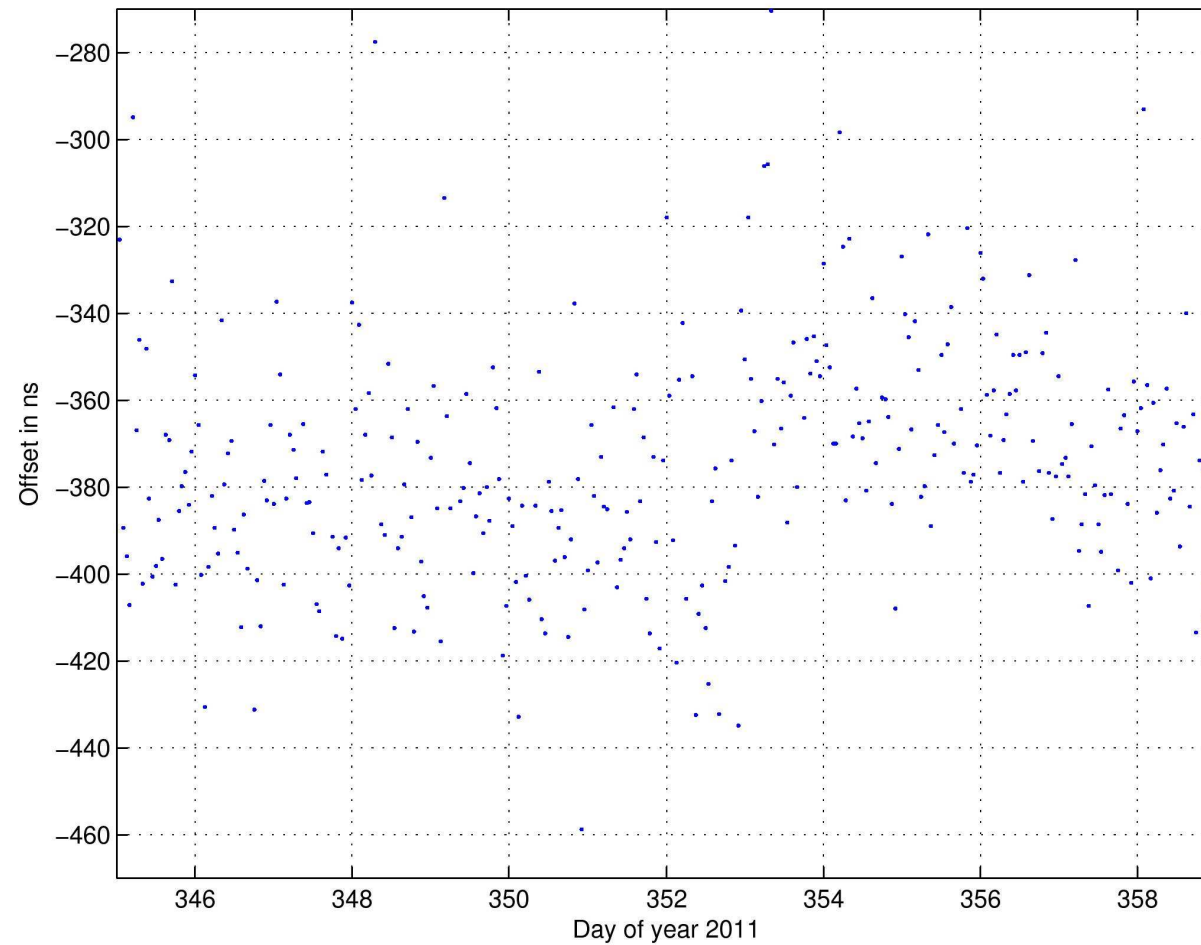


Inter-AC GLONASS bias offsets (per sat): COD-GFZ



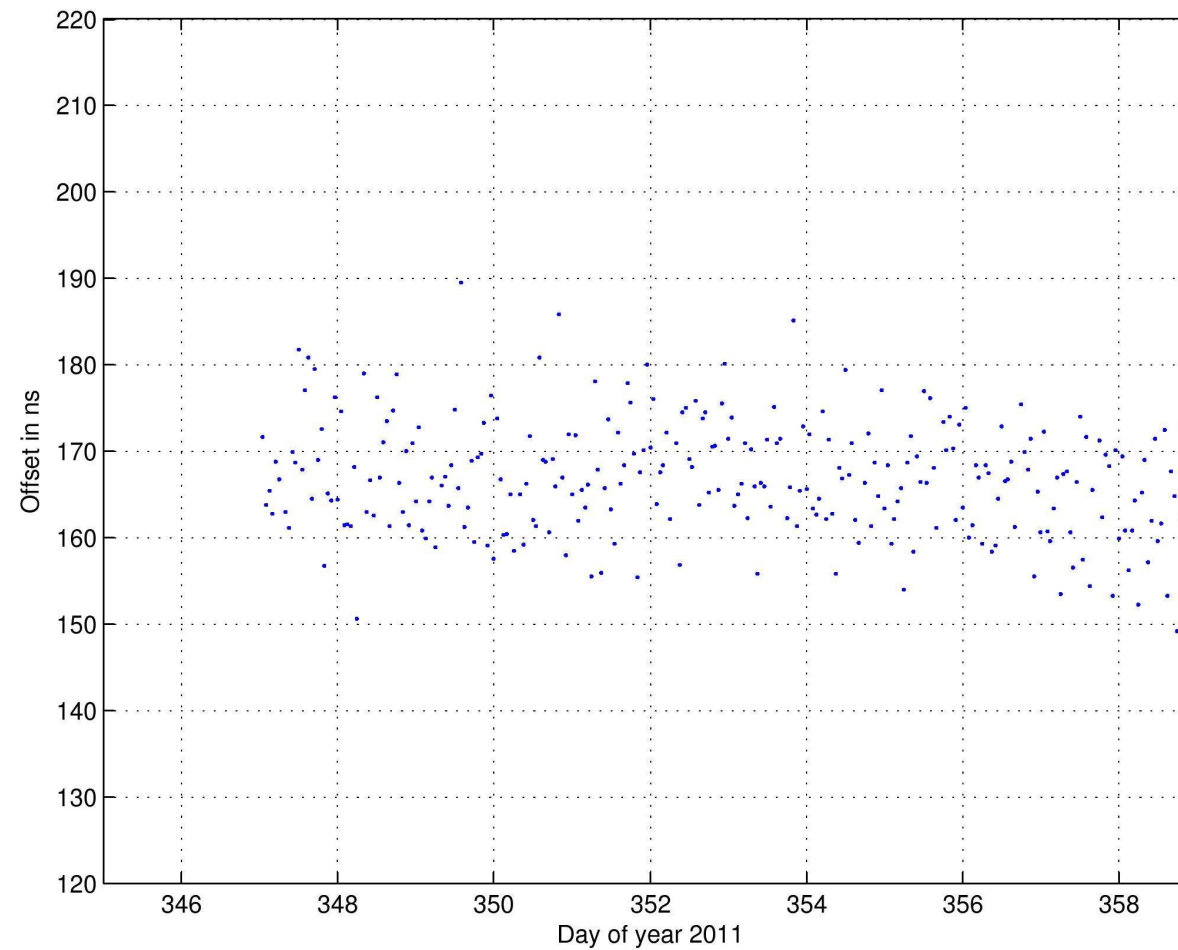


Inter-AC GLONASS bias offsets (per sat): COD-GRG



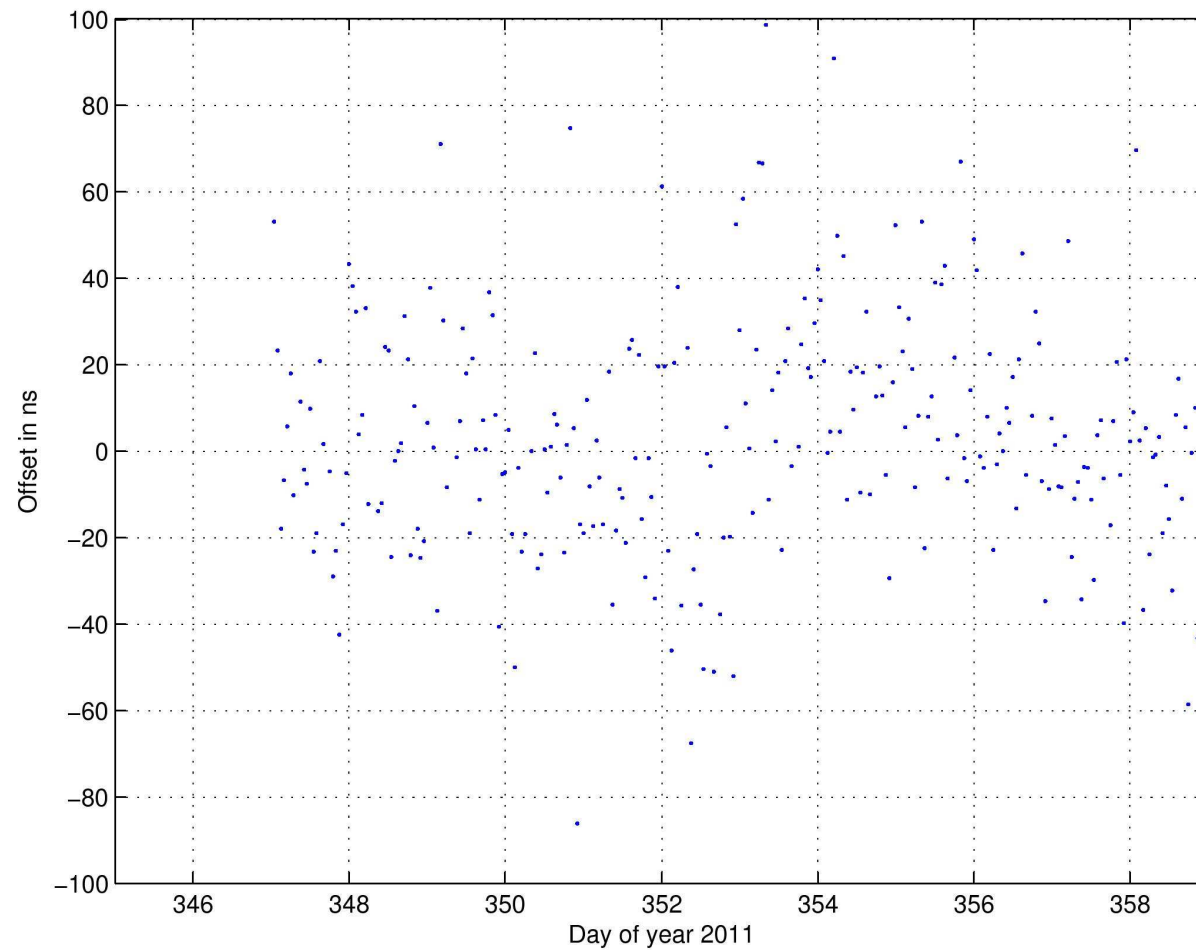


Inter-AC GLONASS bias offsets (per sat): ESA-GFZ



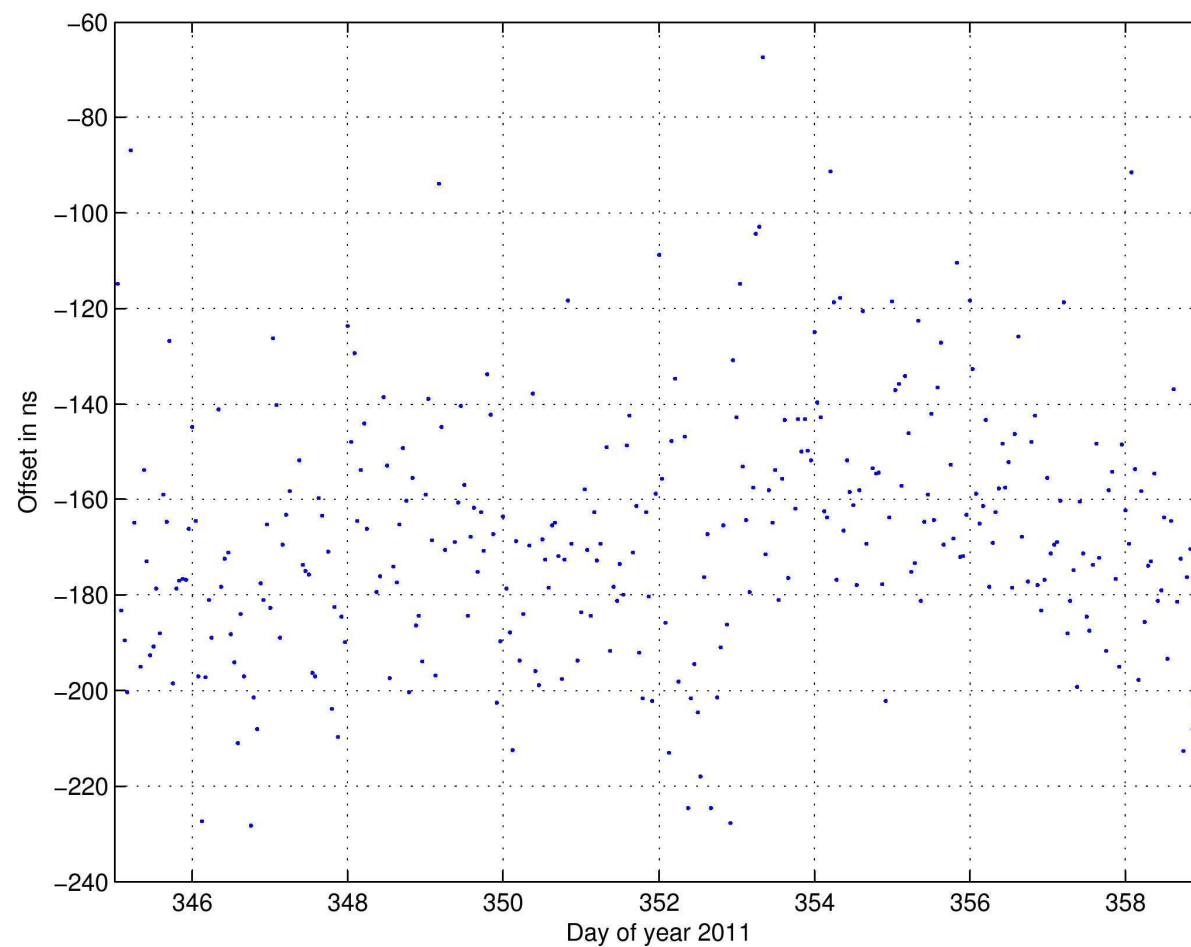


Inter-AC GLONASS bias offsets (per sat): ESA-GRG





Inter-AC GLONASS bias offsets (per sat): GFZ-GRG





Summary and conclusions

- Best agreement (smallest std) could be achieved for the comparison between COD and ESA
 - with an overall std of 0.79 ns
 - resulting in a single-AC std of 0.56 ns
- Only 24 constants were necessary to compensate for the GLONASS bias datum definition specific to each AC



Definition of “GLONASS reference biases”



Proceeding towards an IGS-combined GLONASS clock product

- Standardization of datum definition for GLONASS interfrequency code biases
- Provision of associated GLONASS bias values (?)
 - corresponding sets of bias values could be retrieved from each set of AC GLONASS (satellite) clock corrections
- Realignment of AC GLONASS clock information (prior to IGS combination) if indicated
- Inclusion of GLONASS clock information in the IGS clock combination scheme (as it is implemented/available today)
- Open questions:
 - Treatment of receiver clock corrections with respect to GLONASS (?)